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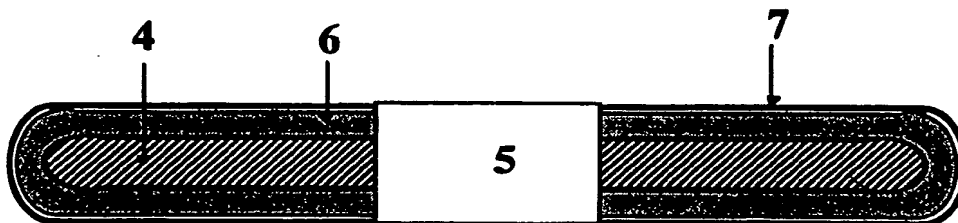
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(54) Title: FILTER CASSETTE



(57) Abstract

There is provided a method for manufacturing a flat, porous, ceramic filter cassette, by manufacturing from a dough or paste, which is produced by mixing a ceramic material together with one or more of the elements binder, plasticizer, dispersant and solvent, flat, porous, ceramic filter bodies for use as coarse filters or substrate for functional membranes in one or more layers, with a large surface-to-volume ratio, the filter body being part cast into a monolithic product, without internal joints or interfaces, in a casting mould consisting of one or more parts, and possibly with inserts which correspond to drainage channels for increased drainage, with a casting material which has sufficiently low viscosity to fill the mould at the moment of casting and which hardens rapidly when the mould has been filled, and that any functional membrane layers are applied in a subsequent secondary process. There is also provided a filter cassette which is manufactured according to the method.

Filter cassette

The present invention relates to flat, porous, ceramic filter cassettes and a method for manufacture thereof, and the use thereof in multi-cassette systems for filtration of liquids and gases.

5 Filter cassettes have been known and used for a number of years by practically all system builders (OEMs) who supply filter systems with flat filters, often referred to as plate-and-frame systems.

From a historical point of view flat filter systems have employed polymeric or organic filters. Since such filters are generally thin and flexible, they
10 require a support in order to be able to function with an external overpressure. Filter packages are therefore constructed with two filters mounted opposite each other, sealed at the edge, and with a physically robust dividing plate in the space between the two filter plates (filter bodies). This acts simultaneously as a separator screen which permits the permeate to be
15 transported in the space between the filters. The permeate can then be retrieved through one or more holes through the filter surfaces. The separator screen may be produced by means of woven webs or by solid, profiled and often hollow plates of polymers or metallic materials, or by combinations thereof. Such filter packages are termed in the literature filter cassettes,
20 filter pockets or filter discs. Industrial filter systems consist of stacks of filter cassettes mounted on top of one another, with an external or internal manifold which distributes the liquid or gas flow over the filter surfaces.

Until fairly recently, ceramic filters available on the market have exclusively been tubular filters. Flat, ceramic filters have not been commercially
25 available in practice until very recently.

Ceramic filters have the following advantages over polymeric ones. They can be sterilised, are wear-resistant, have a homogeneous pore size, can be used in extreme environments (pH 0-14), withstand high temperatures (up to
1000°C), can be back-flushed (cleaned) under high pressure, and have a long
30 life.

At present ceramic individual filters are manufactured by first making a dough or paste consisting of 40-60% ceramic powder, 2-10% binder, 2-10% plasticizer, 1-2% dispersant and 40-60% solvent. This dough can be formed

into tubes and plates (green bodies) by extrusion, pressing, tape-casting or rolling. Green bodies are defined as immature objects, in the sense that they have not been completely processed (usually not fired), and in the following, green describes a state which is not fired. The green components are then
5 sintered at high temperature. During this sintering process all the components are burnt off apart from the ceramic material, and the component emerges as a pure ceramic product. After a supporting substrate with coarse pores has been produced and sintered, one or more intermediate layers of porous ceramic materials are applied. Finally, the desired membrane layer is applied
10 which after sintering obtains the desired pore distribution. Such filters are called asymmetric filters. However, the substrate may also be used as a coarse filter alone.

Flat, ceramic filter cassettes have the following advantages over ceramic tubular filters. In principle they have a higher specific surface (surface
15 area/volume), can be easily adapted to different geometries and offer engineers and designers greater flexibility with regard to the design of the system.

Other ceramic filter cassettes are manufactured by methods which in principle are derived from the production of polymer cassettes [see, e.g., US
20 A 4,902,420 (Pall)]: by laminating the ready-sintered, ceramic plates which form the two filter plates and the separator screen, see JP A 5,228,347 (Horikata), JP A 6,134,267 (Yorita), WO A1 93/00154 (Lescoche), DE A1 43 35 122 (Rennebeck) and US A 4,867,876 (Kopf).

Other patents which cover monolithic, ceramic filters are US A 5,498,288
25 (Noky) and US A 5,114,581 (Goldsmith). These are based on honeycomb structures, which are one-dimensional and which are usually produced by extrusion. Noky's patent covers a method of plugging a selection of the honeycomb structure's channels, while Goldsmith's patent covers the use of such filters in a dead-end configuration. Dead-end configuration means that
30 all filtered liquid passes through the filter, possibly until it is clogged due to deposits on the filter surface. Due to the said plugging Goldsmith achieves a cleaning of the filter surface by applying a counterpressure through the channels which are open at the rear edge. This will permit the deposited filter cake to be lifted from the filter surface, enabling it to be flushed out for
35 subsequent continuation of the real filtering.

In WO A 96/06814 Sekhar has described the manufacture of monolithic, ceramic filters by means of micropyreitic synthesis. This is a new sintering process for three-dimensional ceramic components, as opposed to the present method which covers manufacture of a desired (three-dimensional) shape.

- 5 Another technology for production of ceramic filter cassettes is lamination of the three ceramic plates which form the two filter plates and the separator screen in a green state, and then sintering the ready-laminated body. This is described by Koppe in the patents DE C2 43 30 163 and EP A1 723 799. On the outside of this filter body the active, porous membrane layer is then
10 applied in one or more layers, until the desired pore size has been achieved. The disadvantages of this method are that the product has to be manufactured in several parts and joined/laminated before sintering. This gives a relatively complicated, multi-stage process, with a joining process which makes great demands on accuracy, cleanliness and performance. Defects can arise in the
15 joint, thus reducing the end product's mechanical properties and strength. The same can be said for the method described in US A 5,326,512 (Stillwagon).

According to the present invention a method is provided for manufacturing a flat, porous, ceramic filter cassette according to claim 1 and a flat, porous, ceramic filter cassette produced therefrom, according to claim 10.

- 20 The present invention relates to a monolithic filter cassette and a method for manufacturing monolithic filter cassettes, which can be used for both dead-end and cross-flow filtration. Cross-flow filtration means that the substance which has to be filtered is sent at high speed across the filter surface (thereby dislodging deposited material), while the pure product is pressed down
25 through the surface (perpendicular to the filtrate flow). Cross-flow filtration is superior to dead-end filtration with regard to continuous operation and high efficiency.

- A ceramic filter cassette of this kind consists of a filter body or substrate in an open, porous, ceramic material with large pores ($>1\mu\text{m}$). This filter body
30 forms the structure of the cassette, guaranteeing the mechanical and chemical properties. The active membrane layers can then be applied on the outside (or inside) of this filter body in one or more layers, until the desired pore size has been achieved.

The advantage of manufacturing monolithic filter cassettes is that there are no internal joints or interfaces which can weaken the mechanical properties of the finished product. In addition the manufacturing process is reduced in principle to a single stage process for obtaining an easy to handle, green product, before the final sintering to form a monolithic, ceramic filter body. This filter body is well-suited for application of the active membrane layer(s).

The present invention concerns the manufacture of the filter body by part casting thereof, preferably in such a form that the geometry and appearance are exactly defined. In order to achieve this the green material must be of sufficiently low viscosity at the moment of casting and harden rapidly when the mould has been filled. By this means the casting mould can be filled accurately, and the ready-hardened green filter body has both the exact form desired for the finished product and is easy to handle for further sintering and processing. The most important advantage over Koppe's method is that filter bodies produced according to the present invention do not have internal joining surfaces which can reduce the mechanical properties of the completed filter cassette, but are monolithic, i.e. they constitute a uniform and complete structure (monolithic = made in one piece).

To increase the draining of filtered liquid, the drainage can be improved by various types of insert in the cast. One method is to insert forms corresponding to drainage channels, removing these forms when the filter body is in a dried condition. A second method is to insert an object in a form corresponding to drainage channels, made of a material which can be burnt up during the sintering process. A third method will be to cast the filter bodies with a core consisting of a material with a coarser ceramic powder in order thereby to increase the ready-sintered pore radius. A fourth method will be to cast the filter bodies with a core consisting of a material with additives, such as starch, which will give an increased effective pore radius during sintering.

Figure 1 illustrates a principle diagram of the casting mould for the filter body. The mould consists here of a bottom 1 and a top 2 with, for example, ten individual insert discs 3 for the drainage channels in the final filter body.

Filter cassettes which are manufactured in this manner can have an arbitrary geometry, consisting of everything from a highly symmetrical shape such as circular, via elliptical, rectangular, trapezoidal, to highly irregular, free shapes. Typical thicknesses for the cassettes will be from 1 mm to 10 mm, depending on the mechanical and functional requirements for the cassette.

The common feature of all the shapes is that the cassettes have a large surface area in relation to the volume. One method of achieving this is to give the filter cassette two large, flat surfaces, which may be parallel or non-parallel. These form the active filter surfaces, through which the purified medium is pressed or filtered. The filtered medium is discharged from the cassette through one or more openings through the filter surface or the periphery of the cassette. The periphery can naturally also be used as an active filter, but here the path for the filtered medium through the substrate will often be longer.

Figure 2 shows an intersected filter body with drainage channels and a centre hole for drainage of the filtrate. The drainage channels 4 and centre hole 5 are illustrated in the figure.

The functional membrane may be a microfilter, ultrafilter, nanofilter or an RO filter, consisting of an organic or inorganic material. The active membrane layers can be applied either externally or internally in the cassette. The methods of application of the active membrane layers may be tape casting, slip casting, screen printing, gel casting or sol-gel coating.

Figure 3 shows the cross section of a filter cassette with drainage 4, substrate or support 6, centre hole 5 and membrane layer 7.

Figure 4 is a diagram of the flow pattern over a filter cassette, with the liquid which has to be filtered 8 flowing over the surface of the filter cassette and the pure filtrate 9 which is transported through the drainage out to the centre hole 5 from which it can be transported out.

PATENT CLAIMS

1. A method for manufacturing a flat, porous, ceramic filter cassette, there being manufactured from a dough or paste, which is produced by mixing a ceramic material together with one or more of the elements binder,
5 plasticizer, dispersant and solvent, flat, porous, ceramic filter bodies for use as coarse filters or substrate for functional membranes in one or more layers, with a large surface-to-volume ratio,
characterized in that the filter body is part cast into a monolithic product, without internal joints or interfaces, in a casting mould consisting of one or
10 more parts, possibly with inserts which correspond to drainage channels for increased drainage, with a casting material which has a sufficiently low viscosity to fill the mould at the moment of casting and which hardens rapidly when the mould has been filled, and that any functional membrane layers are applied in a subsequent secondary process.
- 15 2. A method for manufacturing a ceramic filter cassette according to claim 1,
characterized in that the casting process can take place in the presence of an over or underpressure.
- 20 3. A method for manufacturing a ceramic filter cassette according to claim 2,
characterized in that the inserted drainage forms are removed when the filter body is in a dried condition.
- 25 4. A method for manufacturing a ceramic filter cassette according to claim 3,
characterized in that undesired openings after the drainage forms are plugged with plugs of green material.
- 30 5. A method for manufacturing a ceramic filter cassette according to claim 1,
characterized in that the inserted drainage forms are made of a material which disintegrates or can be burnt off during the sintering process.
6. A method for manufacturing a ceramic filter cassette according to claim 1,

characterized in that increased drainage is created by casting the filter bodies with a core consisting of a material with a coarser ceramic powder in order thereby to increase the ready-sintered pore radius.

5 7. A method for manufacturing a ceramic filter cassette according to claim 1, characterized in that increased drainage is created by casting the filter bodies with a core consisting of a material with additives, such as, e.g., starch, which will give an increased, effective pore radius during sintering.

10 8. A method for manufacturing a ceramic filter cassette according to claim 1, characterized in that openings to discharge the filtered medium from the cassette are produced by means of inserts according to claims 1, 5, 6 or 7.

15 9. A method for manufacturing a ceramic filter cassette according to claim 1, characterized in that openings to discharge the filtered medium from the cassette are produced by means of a profile-shaped casting mould.

20 10. A flat, porous, ceramic filter cassette manufactured according to claims 1-9, characterized in that it consists of a filter body which is formed in a green state by a casting process into a monolithic product, without internal joints or interfaces, and that it consists of possible functional membrane layers which are applied in a subsequent secondary process.

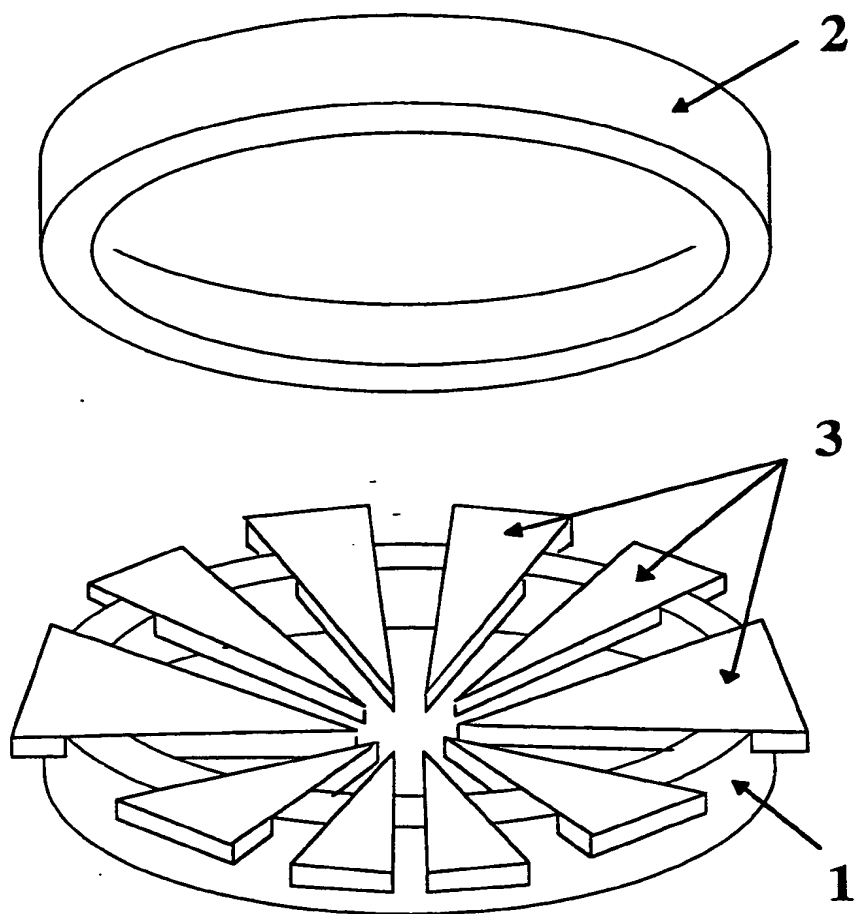
25 11. A filter cassette according to claim 10, characterized in that the functional membrane covers the entire external surface of the cassette.

12. A filter cassette according to claim 10, characterized in that the functional membrane covers the entire internal surface of the cassette.

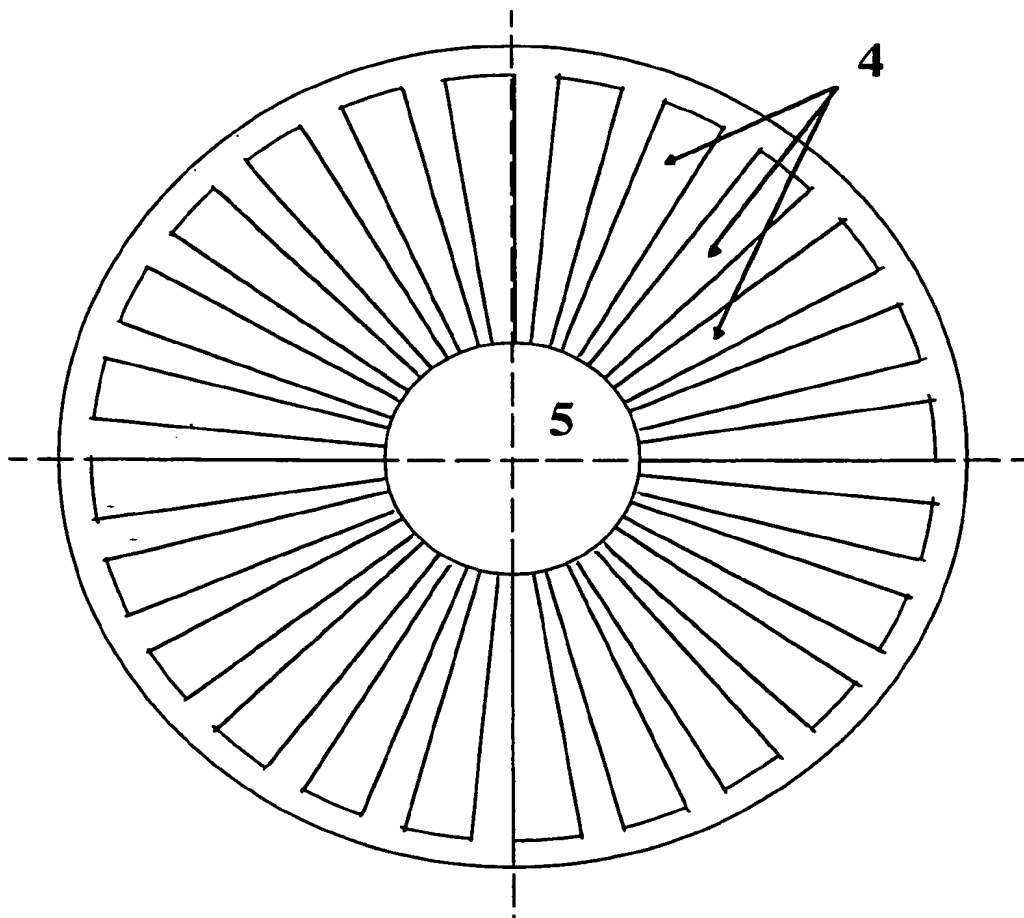
30 13. A filter cassette according to claim 10, characterized in that the functional membrane consists of an organic or inorganic material.

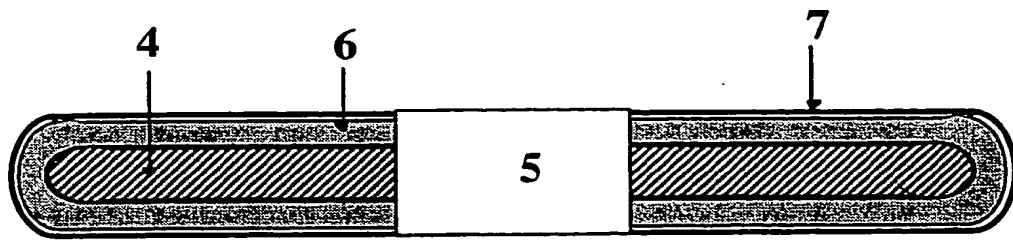
14. A filter cassette according to claim 13,
characterized in that the functional membrane layers are applied by tape-
casting, slip casting, screen printing, gel casting or sol-gel coating.
- 5 15. A filter cassette according to claim 10,
characterized in that it contains one or more openings through the filter
surface or the periphery suitable for discharging the filtrated medium from
the cassette.

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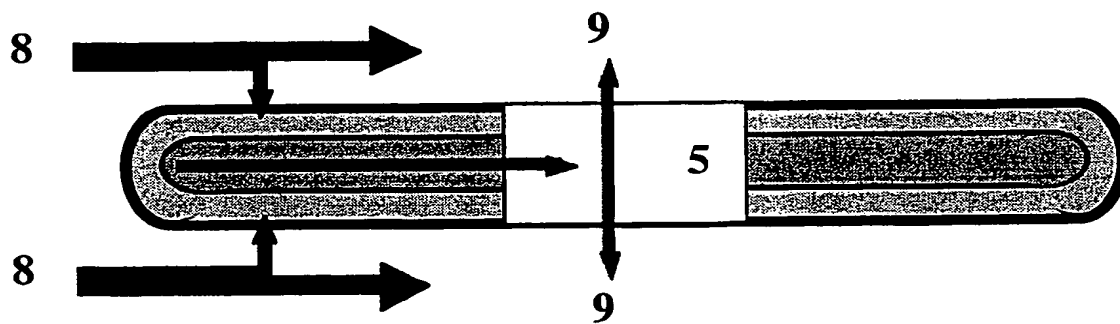
**Figur 1.**

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**Figur 2.**



Figur 3.



Figur 4.